Prototype Testing

To begin testing of the trolley system, a motor with 100 oz.-in. of torque was connected to the trolley. The purpose for using this motor was to physically test the trolley system for the amount of motor torque needed. With the motor on the trolley it was then connected to a power source and turned on. It was found that the motor had enough torque to drive the unloaded trolley. However, when weight was added to the trolley the motor had a very difficult time starting up and continuing movement. This proved that a 100 oz.-in. motor would not be sufficient. Therefore, a motor with 480 oz.-in. of torque was chosen. This motor was tested by adding weight to the trolley and starting it from rest as well as driven continuously. The motor proved to have enough torque to drive the loaded trolley easily.

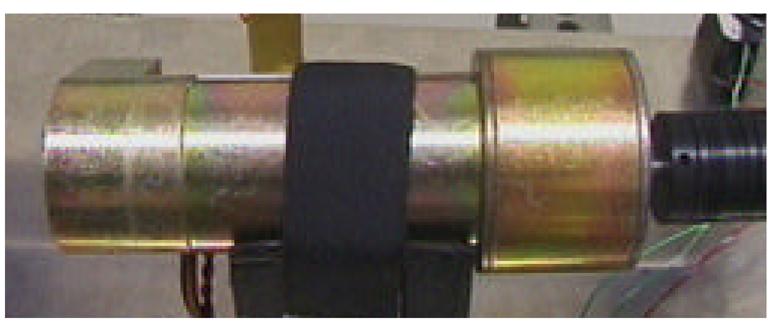

Figure 7.1: 480 oz.-in. Motor Used with Trolley System

The next testing that was performed was for the lateral constraint end caps. The trolley was tested with and without the lateral constraint axle end caps to demonstrate their effectiveness. In doing this it was found that the trolley would twist and turn slightly on the tracks causing the axle ends to rub harshly against the inside of the tracks. This twisting and rubbing caused the trolley to experience difficulty moving. The end caps were then added to the axles and it was found that the trolley rode straight and smoothly on the tracks. This proves that the lateral constraint axle end caps are both necessary and effective.

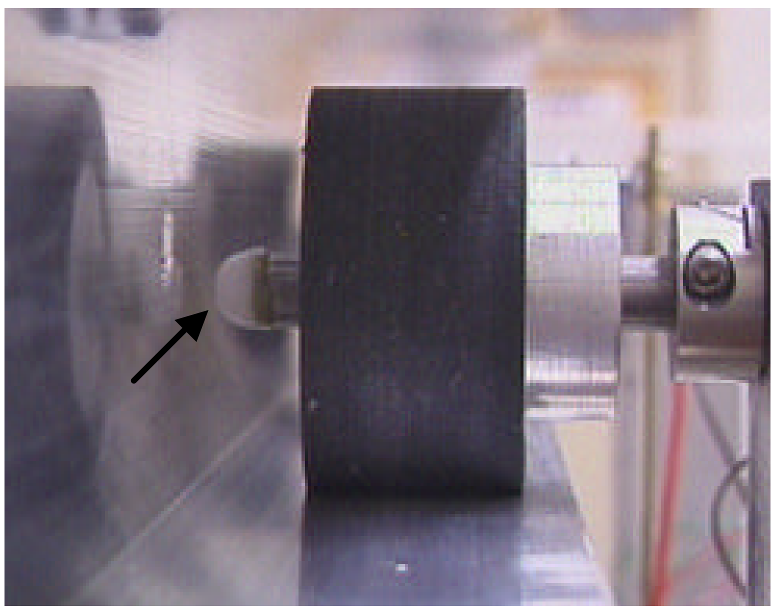

Figure 7.2: Lateral Constraint Axle End Cap

To prove that the system can be truly wireless, testing on the power connection method was performed. To do this, the electrically isolated tracks were connected to a power supply. One track was connected to the positive lead and the other to the negative. The trolley power connection brushes were adjusted to rub along the tracks properly and the power was turned on. The trolley started moving immediately. This was exactly what was desired to occur making the trolley system a success up to this point.

Figure 7.3: Power Connection Arm and Brush

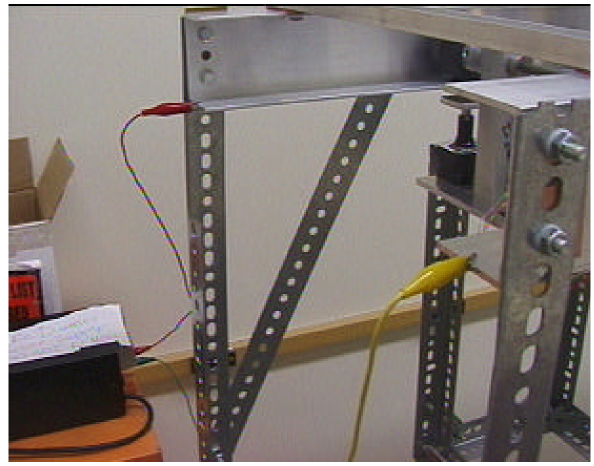

Figure 7.3: Track Power Connection

The next testing procedure for the trolley system was to mount the laser detector to the system and see how it operates. To do this, the tracks were mounted on a five-foot tall support designed and manufactured by two UC Davis undergraduate students. This mount provided the necessary height to simulate a sign truss and perform tests on the trolley system with mounted laser detector. Due to its delicate and unfinished status, the laser detector was not connected to the trolley. However, the actual laser detector mounting frame was used by connecting it to the U-plate and then the U-plate to the trolley. Instead of the actual laser detector, an object with about the same weight was mounted on the laser detector frame. The trolley system was powered and the entire system moved along the tracks rather well.

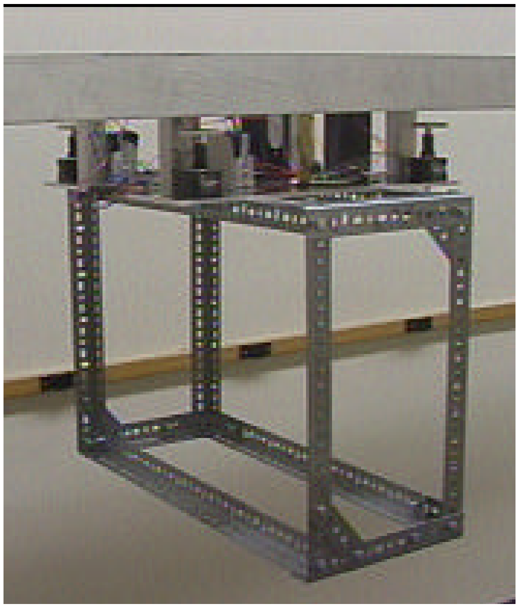
Figure 7.4a: Trolley with Laser Detector Frame

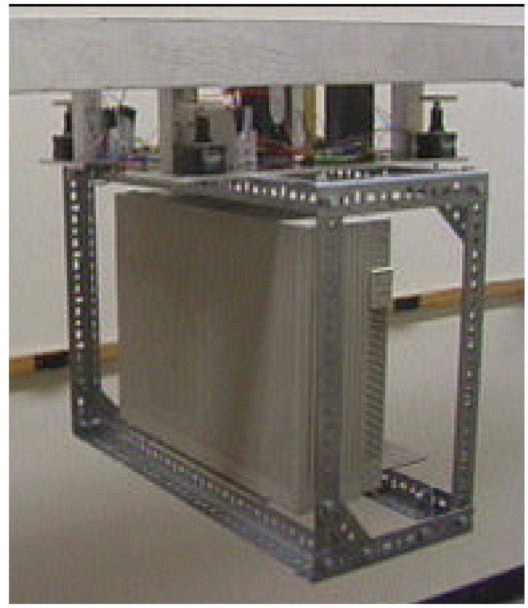
Figure 7.4b: Trolley with Simulated Laser Detector

The drive system was then further tested by applying a force to the laser detector to simulate a direct lateral wind. It was found that the motor would drive the loaded system subject to an applied force with full power until the wheels slipped. The wheels were determined to be the limiting factor for an applied external force. This is exactly what was expected to happen according to the calculations performed in chapter 3.

At this point the trolley system had confidently passed all normal operating condition tests for the moving trolley. Therefore, it was time to test the robustness of the trolley system. To do this, a rather large impediment (approximately 0.25" tall and 1" wide) was placed on the wheels riding surface on one side of the tracks. The fully loaded trolley was driven over the impediment both forwards and backwards. It was found that the trolley had sufficient power to overcome the impediment without twisting, significant slowing, or excessive vibration. This was a very exciting discovery that proves the system is robust enough to overcome any track obstructions that it may encounter.

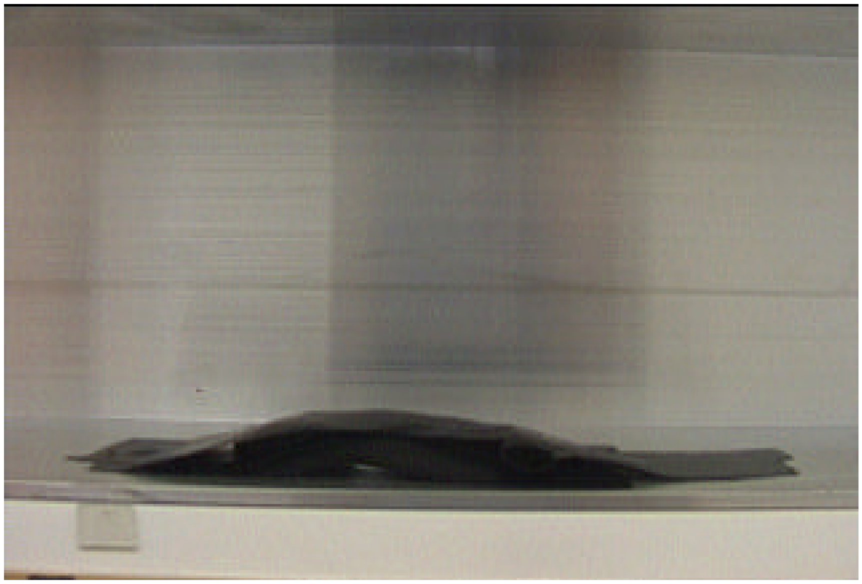
Figure 7.5a: Impediment Used to Test Trolley

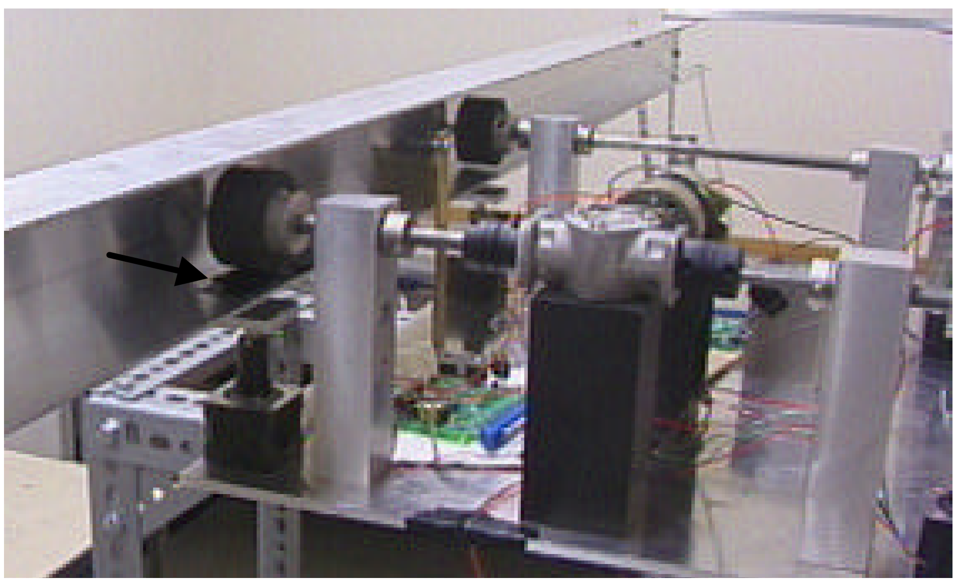
Figure 7.5b: Trolley Overcoming Impediment

The next test for robustness was to examine the trolley's ability to operate in the rain. To do this, first only one track was wetted and the trolley was driven across the tracks. This did not affect the trolley's ability to move; it did not slip, twist, or slow down. Next, both tracks were wetted to simulate operation during a rainy day. The trolley was driven over the wetted tracks without noticeable slipping, twisting, or slowing down. Since wind often accompanies the rain, an exterior force was applied to the laser detector while the trolley drove over the wetted tracks. The trolley was found to slip with a slightly less force applied than when on dry tracks. This was expected do to the decreased coefficient of friction with wet tracks. Nevertheless, the trolley proved to be operational during a simulated rainy and moderately windy day. Again, this was an exciting finding and proved the trolley system to be rather robust.

After finding that the trolley drove well with the mounted laser detector, the next test was to find out how the system operated while in a static position. To do this, the static constraint system was employed, locking the system into position. The first test was a vibration test. The hanging laser detector mount was struck numerous times on different sides to simulate a wind gust. The vibration that the laser detector experienced was minimal. The vibration was found to damp out after approximately one second. Next the tracks were vibrated with different amplitudes causing the trolley to vibrate in response. Again, the vibration that the laser detector experience was minimal and damped out quickly.

Figure 7.6a: Static Constraint System Disengaged

Figure 7.6b: Static Constraint System Engaged

The vibration noticed was almost completely due to the instability in the tracks, not the trolley system. Without manually supporting the tracks (which was done for the vibration test mentioned above) vibrations were slightly larger. These larger vibrations that occurred were due to the unstable track mount. The track mount was built tall but not wide, which created instability to vibrations. In addition, the tracks were supported 8 feet apart. This was done for ease of testing, however on the actual truss the tracks will be supported a maximum of every 5.5 feet. The large distance between the track supports and unstable track mount led to twisting of the tracks, which created excess vibration to be experienced. Even with this instability, the trolley system showed a very reasonable response to vibration.

The next test that was performed was to simply observe the strength of the static trolley with mounted laser detector. The trolley was pushed, pulled, and struck with rather large forces on all sides. It was found that the trolley was extremely strong and firmly attached to the tracks. This proved that the trolley would not get displaced from its precise position over traffic due to external forces. The experimentation also agrees with the calculations made in chapter 5, illustrating that the linear actuators are twice as strong as they need to be.

Since the linear actuators are somewhat strong, a wheel deformation test was also performed. For this test the linear actuators were engaged against the tracks to lock the trolley in place. This caused the wheels to deform slightly due to the somewhat large applied force. The trolley system was kept locked in place with deformed wheels for just over two weeks. The linear actuators were then disengaged and the trolley was driven. It was found that there was no noticeable permanent deformation of the wheels. With permanent wheel deformation, the trolley will experience a bumpy ride. This is not detrimental but is slightly undesirable.

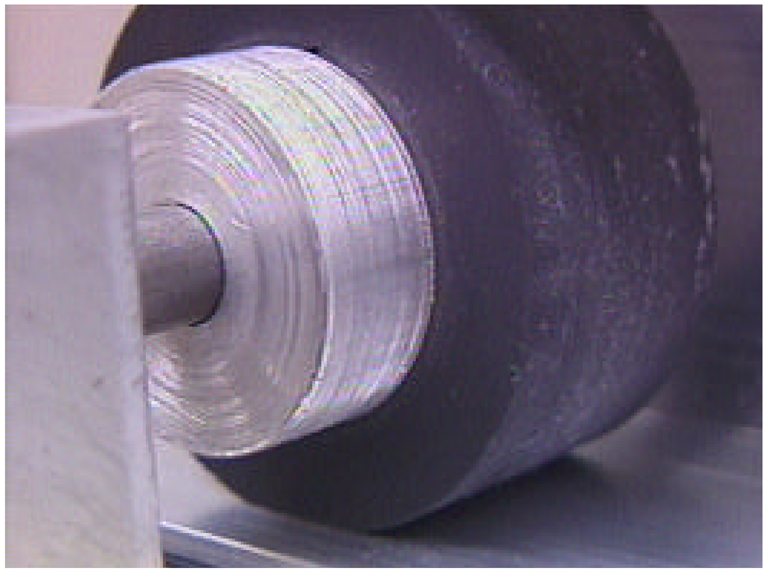

Figure 7.7: Deformed Wheel

With the trolley system performing extremely well, the backup battery was the next item to be tested. To do this, a four-inch section on one side of the tracks was covered with electrical tape to cause the brush to lose electrical contact with the tracks. The trolley was first driven over the discontinuous section, without the battery, attached to see if it, indeed, created an electrical isolation. The trolley was unable to pass the section, regardless of which direction it was traveling. The backup battery was then connected to the motor in parallel with the track delivered power source. The trolley was driven over the discontinuous section again and was able to continue past the section. This proves that the backup battery works and will ensure that the trolley gets to its destination.

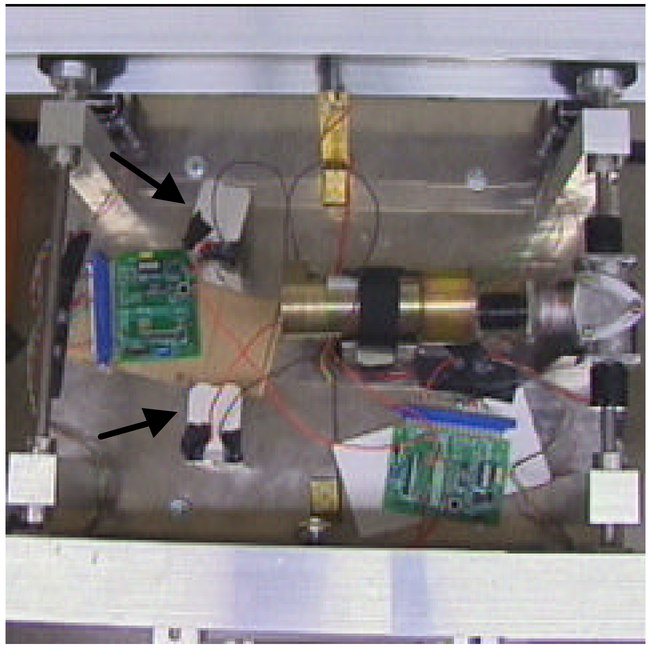

Figure 7.8a: Backup Batteries

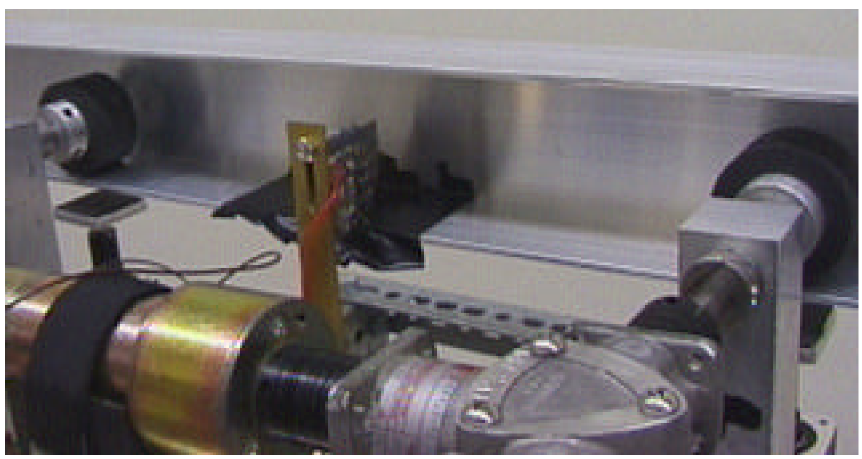

Figure 7.8b: Trolley Overcoming Discontinuous Section Using Backup Batteries

After having the entire trolley tested for multiple aspects, the tracks were put to a couple of simple strength tests. To test the bending strength of the tracks, a 200 lb. load was applied to the pair of tracks with connection points eight feet apart. The tracks were noticed to deform slightly, but plastic deformation did not occur. Part of the observed deformation most likely was due to instability and weakness in the track mount. With this in mind, and the fact that the track connections were 8 feet apart instead of the 5.5

feet that will be used, the tracks easily supported the applied load. The next test was to determine the strength of each track individually. This experiment tested for track strength from wind loading on the trolley. Winds will cause a torque about the center of the tracks, creating equal and opposite bending forces on the individual tracks. To test this, a 160 lb. load was applied to each track individually. The tracks were again noticed to deform slightly, partly due to the track mount, but suffer no plastic deformation. This proves that the tracks will be strong enough to support the trolley and mounted device.

Overall, the trolley system tested with tremendous success. All of the calculations made were upheld through the testing process. The trolley was subject to rigorous testing and proved to pass with flying colors. The testing demonstrated that the mounted device would be safe and secure above traffic. The mounted device will also be able to operate properly because of the robust nature of the trolley. The testing performed on the trolley system proves that it is acceptable to be used as an overhead device mounting system.